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Nesting Biology of the Drywood Termite, *Incisitermes minor* (Hagen)(Abstract_要旨)

AUTHOR(S):

Khoirul, Himmi Setiawan

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京都大学	博士 (農 学)	氏名	Khoirul Himmi Setiawan
論文題目	Nesting Biology of the Drywood Termite, <i>Incisitermes minor</i> (Hagen) (アメリカカンザイシロアリの営巣生物学)		
(論文内容の要旨)			
<p>The western drywood termite, <i>Incisitermes minor</i> (Hagen) (Kalotermitidae) is considered to be the most destructive drywood termite in the western United States (USA) and is one of the five most economically important termites in the USA. Infestation of houses by <i>I. minor</i> was first reported in 1976 from Tokyo, and since then, twenty-four prefectures, from Miyagi to Okinawa, have been infested by the termite. The colonies live entirely within sound and dry wood, and derive their food and water from a single piece of wood. Because of this hidden ecology, <i>I. minor</i> has been easily transported within an infested wood around the world by human activities. In the modern and mobile society, the introductions of such wood-inhabiting termites are very difficult to deal.</p> <p>Although <i>I. minor</i> is an economically important pest, there is very few scientific literature investigated its nest-gallery systems. The most detailed description of <i>I. minor</i>'s biology was provided by Harvey, eight decades ago. The cryptic behavior of this termite hinders studies of its nest-gallery development and colony establishment; thus, the early detection of <i>I. minor</i> infestation is difficult. Mapping the entire gallery system of drywood termites has been technically difficult, with wood dissection being the most common method used. However, wood dissection destroys the fine details of the main chambers, minor chambers, foraging tunnels, and the three-dimensional (3D) connectivity among them.</p> <p>The present study aims to elaborate the nesting biology of <i>I. minor</i>, focuses on the observation of nest-founding activities in the natural environment and X-ray computed tomographic (CT) analysis of the nest-gallery systems of <i>I. minor</i>.</p> <p>Chapter 1 introduces the background, objective and outline of the study. Furthermore, the chapter also explains about the biology of <i>I. minor</i>, and short description of principles and application of X-ray computed tomography used in most part of the study.</p> <p>In Chapter 2, the evaluation of nest-founding activities of <i>I. minor</i> reproductive following the nuptial flight on six commercial timber species was discussed. The timbers included three Japanese timbers, hinoki (<i>Chamaecyparis obtusa</i> Endl.), karamatsu (<i>Larix leptolepis</i> Gord.), and sugi (<i>Cryptomeria japonica</i> D. Don), and three USA timbers, Douglas-fir (<i>Pseudotsuga menziessi</i> Mirbel), western red cedar (<i>Thuja plicata</i> Donn ex D. Don) and spruce (<i>Picea sitchensis</i> Bong. Carriere). The results suggested that <i>I. minor</i> reproductives showed timber preferences in establishing the royal chamber to initiate the colony. The order of</p>			

preferred timber species was as follows: hinoki, spruce, western red cedar, sugi, Douglas-fir, karamatsu. The current results showed nesting preferences among these six commercial timbers corresponded to previous report on feeding preferences.

The infested timbers were recorded in detail by identifying position of excavated holes on timbers (sapwood, heartwood, and border line of sapwood and heartwood), and the location of excavated holes on timber set-up (closed gap (CG) area, open gap (OG) area, cross-sectional surface (CS) area, bottom surface (BS) area, and upper surface (US) area of the timbers). The reproductives of *I. minor* expressed nest-site selectivity on a preferred part of the timbers, i.e, on the springwood part of the annual growth rings on the sapwood part of the timbers. The reproductives of *I. minor* also showed selectivity in determining their nest-site location in response to the timber arrangement, namely by preferring the CG area. The results corresponded to previous reports which suggested that *I. minor* royal pairs like wood cracks, crevices or holes as sites at which to excavate the first royal chamber.

Chapter 3 presented X-ray tomographic analysis of the structure of initial chambers excavated by *I. minor* as part of nest-founding activities and foraging. The structure of initial chamber excavated by the royal pair of *I. minor* resembled European pear-shape and cashew-net shape, in response toward timber anatomical properties. Those chambers were established the springwood of the sapwood, and were carefully excavated beneath the surface to follow the direction of annual growth rings, and avoided the summerwood. The chapter also presented the structure of initial chamber which was established by group of foragers, mediated by the foraging activities of individuals that had emerged from their natal nest to attack adjacent surface of new timber. The results indicated that drywood termite has greater foraging flexibility in response of environmental conditions.

Chapter 4 reported the first-year development of royal chambers and incipient colonies following the nuptial flight of *I. minor* reproductive as monitored by X-ray CT. The chapter provided important information regarding the nesting biology of the royal pairs in the very early stage of colony founding. Royal pairs of *I. minor* can start breeding new colony members in the first six months, and by the end of the first year, an incipient colony can have 0 – 5 new members. The development of royal chambers in the first year showed a preference for the springwood part of the particular growth rings where the entrance holes were excavated.

Chapter 5 presented X-ray tomographic monitoring of the colonization process of foraging groups of *I. minor* in previously unoccupied timber and discussed how the groups maintain their nest-gallery system. The study also

examines the caste composition of isolated groups in search of a better understanding of how one-piece nester types sustain their colonies. In extending the nest-gallery, *I. minor* also expressed selectivity in foraging by selecting favorable excavation areas, and showed adaptability with respect to the timber environment. In the absence of primary reproductives, the colony showed dynamic change in its caste composition through the emergence of replacement reproductives. The results also suggested that replacement reproductives can emerge from the pseudergate stage. However, the sexes of the replacement reproductives, the time interval before they emerge and the suitable conditions required to facilitate the emergence of replacement reproductives are not yet fully understood.

Chapter 6 provided important insights into how drywood termites establish and maintain their nest-gallery systems in response to the internal structure of fibers, growth rings and other anatomical properties of timbers. The chapter revealed the selectivity of *I. minor* in its foraging pattern and its adaptability with regard to the timber environment. During colonization and foraging within wood, the internal structures of fibers and growth rings and other anatomical properties influenced the way drywood termites established their nest-gallery. The nest-gallery excavations demonstrated continual adaptation by foragers to anatomical constraints in selecting favorable areas of less dense wood fiber inside the timbers. The colony also exhibited defense mechanisms with which to protect the colony, such as by sealing a tunnel leading to the outer environment using cement pellets. The sticky hydrated pellets were observed in the chambers inside the nest-gallery, even in the first six months of new nest establishment.

注) 論文内容の要旨と論文審査の結果の要旨は1頁を38字×36行で作成し、合わせて、3,000字を標準とすること。

論文内容の要旨を英語で記入する場合は、400～1,100 wordsで作成し
審査結果の要旨は日本語500～2,000字程度で作成すること。

(論文審査の結果の要旨)

米国西海岸を原産とするアメリカカンザイシロアリは、1976年に日本国内で初めてその被害が報告されて以来、現在では我が国の半数以上の都府県でその被害が報告されるようになり、今後も被害の拡大が懸念される重要な外来木材害虫である。本種は木材中に営巣し、基本的にその材中のみで活動を行うことから、加害木材中での生態、特に営巣初期コロニーの生態についてはこれまで全く謎であった。本論文は、アメリカカンザイシロアリ有翅虫の樹種嗜好性を現場で評価すると共に、X線コンピュータトモグラフィー (CT) による営巣初期コロニーの長期的な観察を行い、その営巣生態を多角的に検討したものであり、特に評価すべき点として以下の3点を挙げるができる。

1. 有翅虫の営巣に関する樹種嗜好性を世界で初めて実際の被害建物を用いて検討し、長期間の観察によって信頼性の高い結果を得ることに成功した。他の地下シロアリ種とは全く異なった樹種嗜好性を有することが明らかとなり、今後の予防対策の一助として非常に貴重な情報である。
2. 実大被害材中に形成された初期コロニーに対して文化財用大型X線コンピュータトモグラフィー (CT) 装置による解析を継続的かつ非破壊的に実施することによって、王室の形成から坑道の発達に至る4年間の定量的データを得ることに成功した。世界に類を見ないデータである。
3. これまで断片的な情報しか得られていなかった初期コロニーの発達に関わる種々の特性、すなわち王室形成後の活動休止期間の有無、個体数の変化、生殖階級の消長を含む階級構成の変化、複数コロニーの融合性等について、経過年数の明らかな多数のサンプルを用いることによって多角的な面から統合的に明らかにした。

以上のように、本論文は外来木材害虫アメリカカンザイシロアリ営巣初期コロニーの発達について多くの新たな知見を得るとともに、樹種や木材組織の嗜好性などその防除につながる有用な情報を得ることにも成功しており、昆虫生態学、木質組織構造学、木材劣化生物学および木材保存学の発展に寄与するところが大きい。

よって、本論文は博士（農学）の学位論文として価値あるものと認める。

なお、平成29年2月14日、論文並びにそれに関連した分野にわたり試問した結果、博士（農学）の学位を授与される学力が十分あるものと認めた。

注) 論文内容の要旨、審査の結果の要旨及び学位論文は、本学学術情報リポジトリに掲載し、公表とする。

ただし、特許申請、雑誌掲載等の関係により、要旨を学位授与後即日公表することに支障がある場合は、以下に公表可能とする日付を記入すること。

要旨公開可能日： 年 月 日以降 (学位授与日から3ヶ月以内)